Space Weather Technical Forecast

Issued on Sunday, 25 June 2023 at 01:29 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: Chance of R1/R2 Radio Blackouts throughout. Slight Chance of G1 Geomagnetic Storm to start and especially to end the four days.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity has been Moderate during the past 24 hours with an M1.1 flare from AR3337 at 24/1217 UTC.

There are currently fourteen sunspot regions on the visible disc, however almost all are small and/or magnetically simple. The largest and most complex group is AR3340 in the northwest. This region has undergone notable growth of its intermediate spots with a number of mature penumbra emerging. AR3337 in the far northwest was responsible for the largest flare in the period. Although this region is not particularly visually impressive, it does contain a Beta-Gamma magnetic configuration.

No new Earth-directed CMEs have been observed.

Solar Wind / Geomagnetic Activity: The solar wind, as measured by DSCOVR at L1 has largely been at slightly elevated levels, likely due to a connection to the fast wind of a coronal hole high-speed stream in the far west of the visible disc. An enhancement in solar parameters and a peak speed of 525km/s (strong) at 24/1925 UTC is indicative of a CME arrival at L1. The solar wind density has mainly been within typical background levels in high-single figures ppcc, but with an abrupt increase peaking at 14 ppcc at 24/1929 UTC, coincident with the arrival of the CME. The IMF trended from Moderate to background (weak) levels but increased to become Moderate again late in the UTC day, with a peak of 12nT at 24/2054 UTC. The north-south component has varied erratically between +9nT/-10nT.

Resultant geomagnetic activity was Quiet (Kp2) to Active (Kp4).

Energetic Particles / Solar Radiation: High energy proton flux (greater than 10MeV), as observed by GOES16, was at Background levels.

High energy electron flux (greater than 2MeV), as observed by GOES16 ranged between Normal Background and very briefly High levels, with a peak value of 1080pfu at 24/1445UTC. The associated 24-hour fluence showed a steady then largely declining trend through the day, reaching 2.26e7 integrated pfu at 25/0001UTC.

Four-Day Space Weather Forecast Summary

Solar Activity: Solar activity is expected to be Low, but with a daily chance of becoming Moderate, with isolated M-class flares possible.

Solar Wind / Geomagnetic Activity: Solar wind speeds should decrease early in the period from elevated or slightly elevated levels to background ambient levels. A minor increase is likely on day 3 with the combined effects of a glancing CME impact and onset of a weak equatorial coronal hole high-speed stream with speeds perhaps reaching slightly elevated levels again. Further peripheral high-speed stream effects are possible from a high latitude coronal hole on day 4 (28 Jun).

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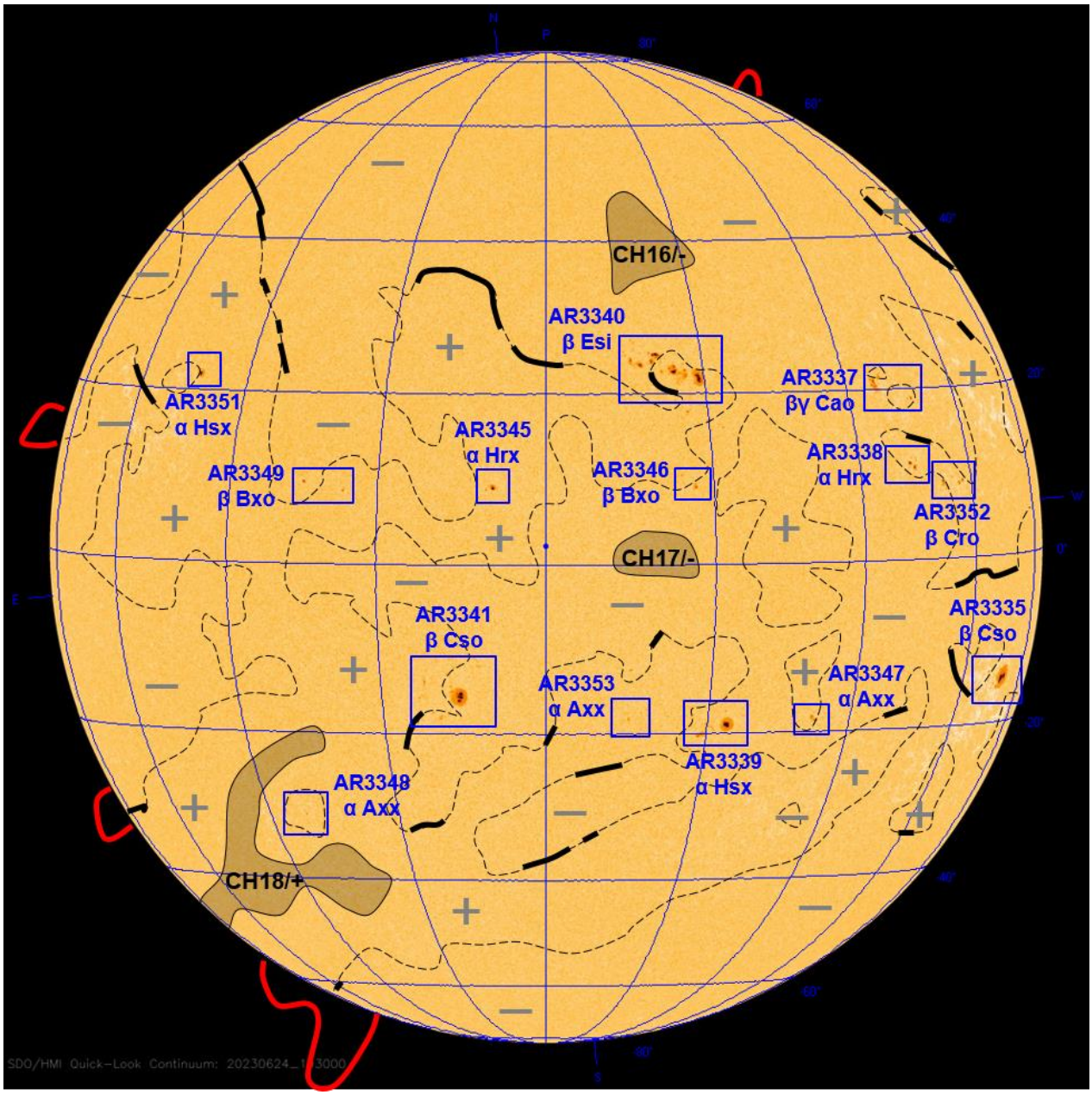
Geomagnetic Activity is expected to be mainly Quiet, but with a chance of Active intervals and slight chance of G1/Minor Storm conditions on day 3 (27 Jun) and very slight chance on days 1 and 4 (25 and 28 Jun).

Energetic Particles / Solar Radiation: The high energy (greater than 10 MeV) proton flux is expected to remain at Background levels, with a negligible chance of S1 or greater.

High energy electron flux (greater than 2MeV) is expected to remain near currently observed levels in the period, though probably dropping from day 3 (27 Jun). The corresponding 24-hour integrated fluence expected to remain under the Active threshold throughout.

Figure 1. Solar Analysis Valid 24/1930 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

A glancing impact from a CME is thought to have arrived at L1 and Earth late in the the UTC day on 24 Jun. Residual geomagnetic effects from this are likely to linger into early day 1 (25 Jun), especially with the solar wind already slightly enhanced from coronal hole high-speed stream influences, although this is expected to ease through the day to more ambient conditions.

In addition to the above, there is a further glancing incidence CME in the forecast - that emitted from the southeast-directed filament tied to the 22/2344UTC M4.8 from AR3341. This shows as a glancing blow, with the majority of the CME passing below Earth. It is expected to pass 1AU early on Day 3 (27 Jun). This 22 Jun CME may arrive in conjunction with a minor CIR of CH17 to bolster its effects. CH17 is a new and very small negative coronal hole currently located just west of the solar meridian on the solar equator. Another larger CH is present at a similar solar longitude in the northern hemisphere at high latitudes. CH16/- is a recurrent feature and may impart some influence at GEO during the forecast period, with peak speeds of around 500km/s observed during the previous rotation. However, the coronal hole appears smaller than last time, so may be slightly weaker overall. This feature appears to be well-modelled by Enlil, which indicates that the majority of the high-speed stream will pass above Earth orbit, but with peripheral effects possible on day 4 (28 Jun). Neither CH16 or CH17 are expected to be particularly impactful on their own given our proximity to the solstice, and in the absence of any CMEs there is perhaps a chance of Active intervals at peak and a very slight chance of G1/Minor Storm intervals on day 1, 3 and 4 (25, 27 and 28 Jun) with day 3 favoured due to the anticipated CME and weak CIR arrival. Otherwise, mainly Quiet conditions should dominate the period.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	5	1	15	5
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
23/0714 UTC	Partial	Filament eruption triggered by M4.8 flare from AR3341	SE quadrant	476 km/s	Early 27 Jun	Glancing blow from significant minority of MOSWOC Enlil ensemble members

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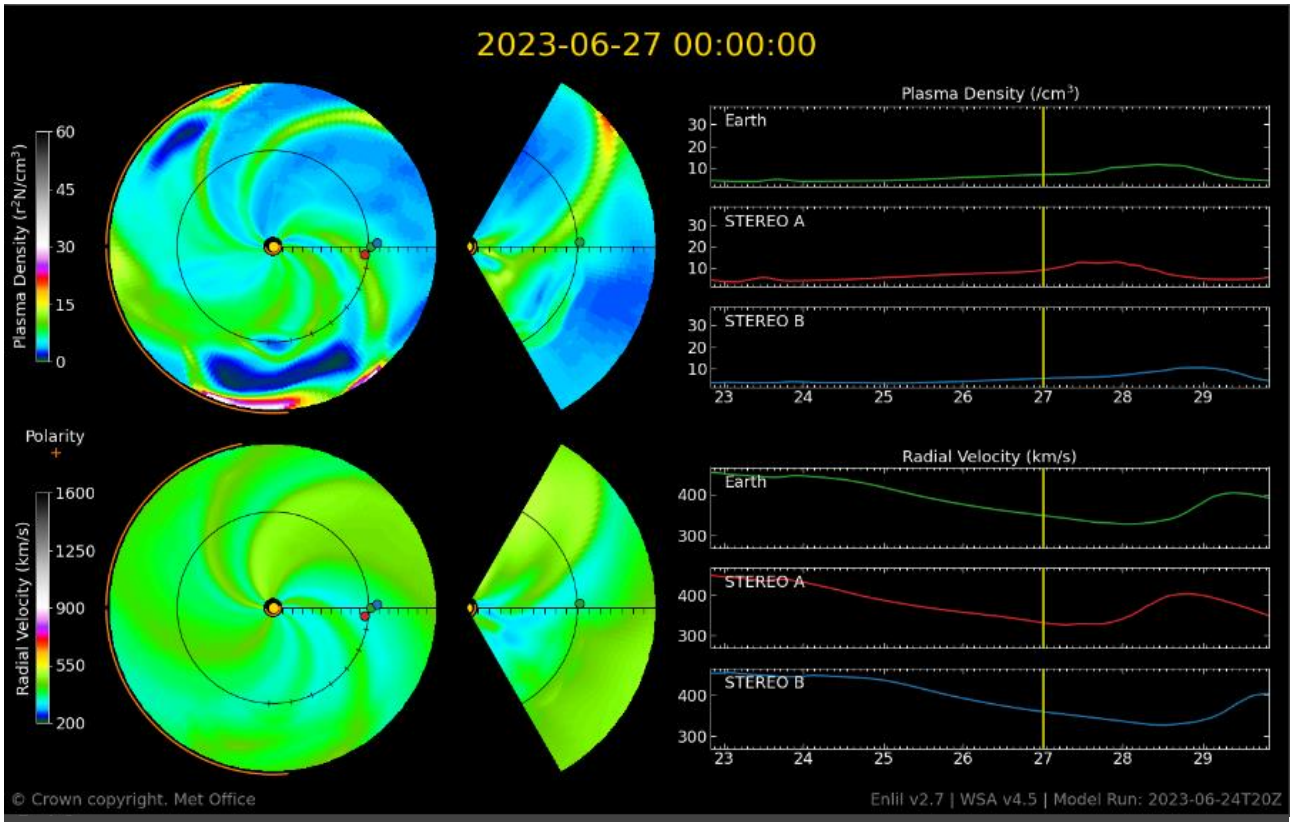
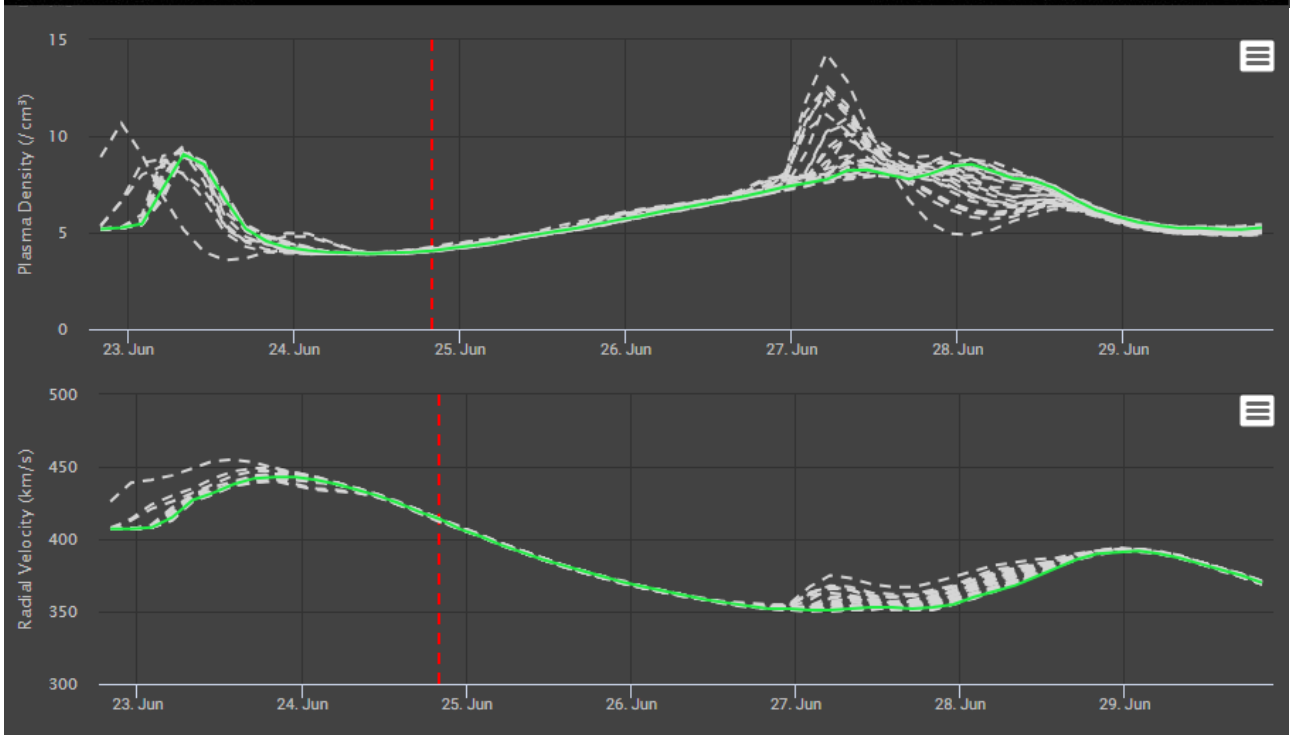
Figure 2: MOSWOC Enlil and Ensemble





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Radio Blackouts - X-Ray Flares:

There are currently fourteen sunspot regions on the visible disc, however almost all are small and/or magnetically simple. The largest and most complex group with the greatest potential for flares is AR3340 (Esi/Beta). This region is approaching the central northwestern quadrant and has undergone recent notable growth of its intermediate spots with a number of mature penumbra emerging. The largest flare of the past 24 hours is an M1.1 event from AR3337 (Cao/Beta-Gamma) at 24/1217 UTC. Although the region is not particularly visually impressive it does contain a Beta-Gamma magnetic configuration.

Far-side soundings and STEREO A EUVI195 imagery suggest a minor new region may rotate over the eastern limb early on day 2 (26 Jun), otherwise there is nothing imminent of note due over the eastern solar horizon from an Earth perspective. In the western hemisphere a number of sunspots (AR3335, AR3337, AR3338 and AR3352) will depart the visible disc in the coming days. On balance then, because of recent trends in current spots and the expected net loss of sunspot regions, there is a reducing chance of M-class flares with time, barring any new developments.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	Yes	30	30	20	20
Very Active	R3 to R5 X Class	No	2	2	2	2

Solar Radiation Storms - (High Energy Protons):

The high energy (greater than 10MeV) proton flux, as observed by GOES16, is at Background levels and expected to remain so throughout the period.

There remains a daily, very slight chance of reaching the S1/Minor Storm threshold given the sheer number of sunspot regions on the visible disc. Even with the more significant sunspots moving into a more favourable location to connect magnetically with Earth in the coming days, a number of sunspots will also rotate over the western horizon. On balance the risk is likely to remain steady, but negligible in the absence of any significant sunspot development.

Radiation Storms	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	≥ S1	No	5	5	5	5
Very Active	≥ S3 *	No	1	1	1	1

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Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	5	5	5	5
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

High Energy Electrons Event (≥ 2MeV):

High energy electron flux (greater than 2MeV) is likely to continue to follow its recent trend of diurnal variation between Normal Background and Moderate to High flux, at least early in the period. While the geomagnetic forecast is relatively complex for the period, it is not expected to be especially impactful, particularly with regard to electrons. Any fast wind enhancements are expected to be of a similar or lower magnitude to that seen recently, i.e. around 400-450km/s. Electron counts should lower in response to the expected CME and CIR on day 3 (27 Jun), with any resultant increase following this, likely outside the current forecast period.

MOSWOC REFM is currently offering a forecast significantly below persistence levels, which is accepted, with only a very slight chance of exceeding the Active threshold on day 1 and 2 (25 and 26 Jun).

GEO Electron Environment Probability (Exceedance)	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^8$**	No	10	10	5	5
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	1

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Figure 3: Latest GOES16 Electron Flux (above) and MOSWOC REFM output (below).

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